Monday 1 September

Session 1: Quantum Optics – Entangled Photons (11:30 – 11:45, Huxley LT311)

Production and analysis of qubit entanglement on a silicon photonic chip

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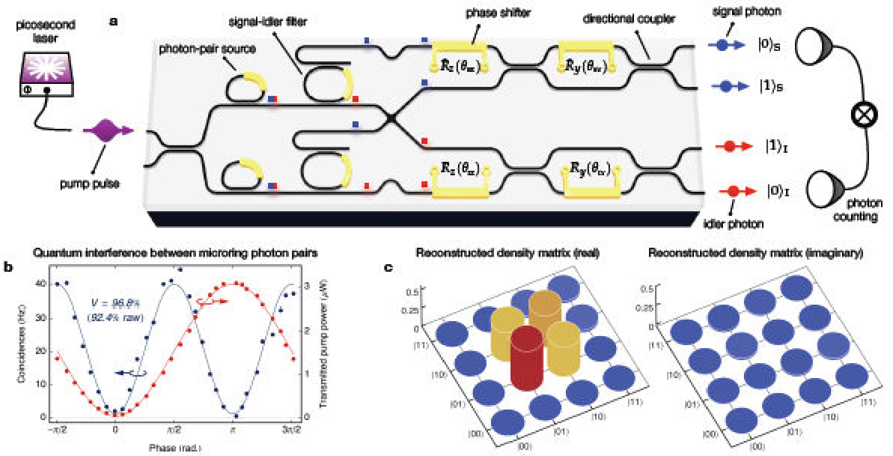
Silicon quantum photonics promises to take quantum optics to the large scale, where single photons carry the quantum information which can accelerate difficult computational problems, provide perfectly secure communication, or allow high-accuracy measurements. The silicon photonics platform offers miniature, high-yield, and high-performance photonics which are integrable with CMOS electronics and telecommunications-band optics.

To date, only non-scalable photon-pair sources, based on spontaneous four-wave mixing (SFWM) in straight silicon waveguides have been shown to interfere [1]. Until now, single-photon experiments in silicon [2] have exclusively used an off-chip apparatus, such as a silica arrayed waveguide grating, to control and manipulate photon frequency. We present a silicon-on-insulator quantum photonic device (Fig. 1a) able to generate and analyse two maximally entangled qubits. We use this device to demonstrate high-visibility quantum interferencebetween resonant SFWM sources (analogous to [1]), phase-stable frequency-selection, and quantum state tomography.

We varied the phase θ_{IZ} to obtain the fringes shown in Fig. 1b, with a visibility of 96.8%. This high visibility indicates that the two microring sources are substantially identical. We setup the entangled state via the on-chip 17-dB extinction filters, and used quantum state tomography to analyse it (Fig. 1c). We measured a fidelity of

$F = \langle \Psi^+ | \rho | \Psi^+ \rangle$= 0.8.

This is the first time an entangled state of photonic qubits has been both generated and analysed on-chip, and this generation has been done in a way which is scalable to larger photon number. These results represent a new step towards fully silicon-integrated quantum photonics.



[1] J. W. Silverstone et al., \On-chip quantum interference between silicon photon-pair sources," Nature Photon. 8, 104{108 (2013).

[2] D. Bonneau et al. \Quantum interference and manipulation of entanglement in silicon wire waveguide quantum circuits," New J. Phys. 14, 045003 (2012).